ABSTRACTS OF RECENT LITERATURE

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Abstracts are drawn primarily from the orthotics and prothetics literature. Selections of articles were made from these journals:

Acta Orthopaedica Scandinavica
American Journal of Occupational Therapy
American Journal of Sports Medicine
Archives of Physical Medicine and Rehabilitation
Journal of Bone and Joint Surgery
Clinical Prosthetics and Orthotics
Engineering in Medicine
Physical Therapy
Physiotherapy
Prosthetics Orthotics International
Rehabilitation Literature

BARRY DT, LEONARD JA JR, GITTER AJ *(Department of Physical Medicine and Rehabilitation, University of Michigan, Ann Arbor, MI).* **Acoustic Myography as a Control Signal for an Externally-Powered Prosthesis.** *Arch Phys Med Rehabil* 67:267-269, 1986.

Nine nondisabled adults and two below-elbow amputees who had never worn prostheses participated in initial trials of an acoustic myography system. The system is based upon the phenomenon that contracting skeletal muscle generates sounds which can be recorded with a standard microphone. A linear relationship exists between sound amplitude and isometric force.

In the prosthetic control system, a standard phonocardiograph microphone transduces the sound. The microphone is placed over any muscle belly which the individual can contract and relax voluntarily. The resulting electrical signal is amplified, filtered, and rectified to produce a control signal with a variable time constant set to 0.2 sec. A variable delay and high amplitude signal eliminator discriminate between active muscle sounds and environmental noise, such as banging on a table or loud conversation. The processed signal is used for tristate control with a standard myoelectric hand. The system circuitry costs $50. All subjects could manipulate objects with the prosthesis within 15 minutes of receiving the equipment and did achieve good control with 20 to 30 minutes of practice.

The system does not require direct skin contact; thus, a sock or wound dressing may be interposed between the microphone and the skin. Changes in skin impedance, as from sweating or grease, do not affect the signal. Electrical shielding is much less a problem. The signal is less sensitive to precise placement over the muscle as compared with surface electromyography. Extraneous environmental noise can interfere with the signal, but the problem may be avoided with the use of two microphones of differential amplification so that signals detected simultaneously are ignored. The system may not be as effective for multistate control.

BECK C, DREZ D JR, YOUNG J *(Louisiana State University Medical School, New Orleans, LA).* **Instrumented Testing of Functional Knee Braces.** *Am J Sports Med* 14:253-256, 1986.

Three patients with severe anterior cruciate ligament laxity were each fitted with seven knee orthoses: CTi, Don Joy 4-Point, Feanny, Generation II, Lenox Hill, Lerman, and RKS. Each subject's injured knee was examined by arthroscopy to confirm the ligamentous laxity. Testing of anterior tibial displacement was done with two devices, the Medmetric KT-1000 and the Stryker Knee Laxity Tester. Knees were tested between 25 and 30 degrees of flexion.

No statistically significant differences among the orthoses was detected by the KT-1000 device, al-

though orthoses were ranked: (1) Don Joy 4-Point, (2) Generation II, (3) RKS, (4) Lenox Hill and Feanny, and (5) CTi and Lerman. With the knee laxity tester, the Feanny and Lerman orthoses provided less control than the other appliances. The prefabricated Don Joy consistently demonstrated greater effectiveness than the Lerman and Feanny. Hinge, post, and shell type braces consistently performed better than the hinge, post, and strap type. As loading on the knee increased, the orthoses decreased their control.

BILLOCK J *(Orthotics and Prosthetics Centre of Warren, Warren, OH).* **Upper Limb Prosthetic Terminal Devices: Hands Versus Hooks.** *Clin Prosthet Orthot* 10:57-65, 1986.

Prosthetic terminal devices offer very little true functional restoration of the human hand, which has precision, dexterity, and sensation. Devices are either body-powered with Bowden cable control or electric-powered with myoelectric or switch control. Bowden control requires adequate force and excursion and produces sensory feedback related to force and position. Myoelectric control utilizes the neuromuscular system for control and enhances the feasibility of designing a totally self-contained and self-suspended prosthesis. Switch control systems utilize motion and force generated by fine body movements, requiring considerably less force and excursion than a Bowden system. Mechanical hands are more aesthetic than hooks, but weigh much more and offer less dexterity and durability. Encouraging the use of a hook instead of a mechanical hand is intended to develop appreciation for the functional advantages of the hook, but may be the primary cause of the high incidence of prosthetic rejection because of social-psychological responses.

Electric-powered hands, introduced into clinical practice in the early 1960's, have a major functional advantage over mechanical hooks and hands, namely finger prehension force equal to, or greater than, the human hand. Electric hands provide three jaw chuck palmar prehension, enhancing overall functional value. The only electric-powered hook is the Griefer, which provides forceful prehension with multiaxis fingers, but the device is heavy and not durable.

Experience with over 300 individuals with congenital and acquired deficiencies at all upper-limb levels indicates that more than 95 percent prefer a prosthetic hand to a hook. Only 1 percent of those provided with a prosthetic hand have a mechanical one; 80 percent of the hands are myoelectrically controlled. The rejection rate for a powered hand is approximately 15 to 20 percent, considerably less than for a conventional prosthesis. Social-psychological needs must be of primary concern before vocational needs can be addressed effectively. Unilateral amputees do not use the prosthesis for fine motor prehension, but for gross prehension, holding, and stabilizing objects.

BILOTTO S *(Yonkers, NY).* **Upper Extremity Cosmetic Gloves.** *Clin Prosthet Orthot* 10:87-89, 1986.

Technology for producing cosmetic gloves has changed little in more than 20 years. Gloves have been made with latex, urethanes, and RTV silicones, but these materials have disadvantages. Latex coloration is unacceptable. The material tears easily, absorbs clothing dyes, and deteriorates quickly. Urethanes are too sensitive to moisture and contaminants during manufacturing and are weakened by ultraviolet light. Room-temperature curing silicones require complicated molding procedures, tear easily, and are not very elastic or flexible.

Polyvinyl chloride dominates glovemaking. The material is inexpensive and can be fabricated in metal molds or flexible slush molds, in which the plastic cures against the wall of the mold, producing a thin vinyl skin which can be colored. Stabilizers and plasticizers make the glove flexible and resistant to ultraviolet light. However, the material does not resist chemical attack, stiffens at cold temperatures, and darkens at warm temperatures. The material does not feel human and presents a cadaverous appearance. It does not last more than 8 months. Putting on a polyvinyl chloride glove is difficult and necessitates unsightly zippers.

However, silicone gloves are tougher, more resilient, more durable, and more permanent, resisting chemicals almost completely. Temperature variations have little effect on silicone skins. Color pigments adhere much better. The material is nontoxic, unlike polyvinyl chloride. Silicone can reflect and absorb light, producing a more life-like appearance. Its higher coefficient of friction resists slipping of held objects. Silicone is costlier to manufacture but improved technology should achieve economy. Silicone compounds are presently used in maxillofacial and breast prostheses.

BURKHEAD EJ, SAMPSON J JR, MCMAHON B *(Department of Human Services and Studies, Florida State University, Tallahassee, FL).* **The Liberation of Disabled Persons in a Technological Society: Access to Computer Technology.** *Rehab Lit* 47:162-168, 1986.

Computer applications enhance physical restoration, cognitive retraining, education, vocational exploration, independent living, environmental control, job placement planning, and employment. Technology is influenced by the development of pertinent software and improvements in hardware, especially independence from mainframe computers. Providing disabled persons with direct access to computer technology may be as important as architectural accessibility. Obstacles to computer use include resistance to change, difficulty of selecting suitable equipment, ethical concerns about access to confidential records, and the focus of technology on use by the practitioner rather than the client. A major problem is the practitioner's lack of knowledge and resistance to change.

When disabled persons use the same equipment as able-bodied individuals, they experience marked improvement in their sense of self-worth and sense of independence. Consumers should be treated as problem-solvers with regard to assessing needs, using adaptations of existing technology, and developing new products. A model derived from systems theory and human factors research provides the structure for matching the user's capabilities with existing hardware and software: requirements analysis, functions analysis, task analysis, interface analysis, and field evaluation.

Developing devices may use both the modified software approach and the transparent access approach, the latter being preferable because it allows the client to use standard software.

COLVILLE M, LEE C, CIULLO JV *(Department of Orthopaedic Surgery, Wayne State University School of Medicine, Detroit, MI).* **The Lenox Hill Brace: An Evaluation of Effectiveness in Treating Knee Instability.** *Am J Sports Med* 14:257-261, 1986.

Forty-five young adults were fitted with the Lenox Hill brace. All subjects' knees had demonstrated absent or functionless anterior cruciate ligament on arthroscopy or arthrotomy. Seventy percent also had meniscal injury; moreover, 30 percent had medial collateral, and 43 percent had lateral collateral injuries. None had anterior cruciate repair or reconstruction. Knees were reexamined from 15 to 168 months after injury; the brace was worn from 12 to 48 months. Anterior tibial subluxation at 20 degrees of knee flexion was measured with a Medmetric KT-1000 device while the subject was in and out of the orthosis.

Bracing failed to change the degree of mediolateral laxity in all but one knee. Maximal anterior laxity was 12.1 mm for the injured knee as compared with 5.9 mm on the opposite noninjured knee. With the orthosis, the excursion diminished to 11.5 mm clinically insignificant. The low-energy passive drawer test caused significantly less displacement with the brace. The orthosis also improved rotary stability in nearly all cases, particularly those with the most severe instability. Although most subjects reported fewer episodes of the knee "giving way" with the brace, 62 percent reported some symptoms with the brace. All subjects were involved in athletics, although none was an elite athlete. Twenty-two percent returned to preinjury level of performance and wore the brace only for protection. Forty-seven percent could regain preinjury performance with the brace. Nine percent were not improved by the brace. Sixty percent wore the orthosis for strenuous twisting sports only, and the others wore it for all sports except jogging. All dislike the brace for running because the brace migrated distally. The Lenox Hill brace did not change absolute laxity but did increase resistance to displacement and rotatory instability.

CULHAM EG, PEAT M, NEWELL E *(Department of Physical Therapy, Elborn College, University of Western Ontario, London, Ontario, Canada).* **Below-Knee Amputation: A Comparison of the Effect of the SACH Foot and the Single Axis Foot on Electromyographic Patterns During Locomotion.** *Prosthet Orthot Int* 10:15-22, 1986.

Ten unilateral below-knee amputees were fitted with temporary prostheses which permitted interchanging SACH and single-axis foot-ankle assemblies. Prostheses were aligned to suit each foot type, and each foot was worn a minimum of 1 week before data were gathered. Electromyographic activity of the vastus lateralis and medial hamstrings was recorded with surface electrodes; activity was

correlated with gait cycle phases with the aid of switches on the heel and medial and lateral sole of the shoe. Subjects walked naturally, at their own speed.

Quadriceps activity was approximately the same with both feet, with peak activity at 10 percent of the gait cycle on the sound limb, 20 percent of the cycle on the prosthetic side with the SACH foot, and 30 percent of the cycle with the articulated foot. Hamstring activity on the sound side peaked at initial contact with the SACH foot and at 10 percent of the cycle with the single-axis foot. On the prosthetic side, hamstrings peaked at 30 percent of the cycle with the SACH foot. With the single axis foot, two peaks were observed, at 10 and 60 percent of the cycle.

Muscle activity on the sound side was unaffected by the type of prosthetic foot, and is similar to that reported for nonamputees. On the prosthetic side, peak activity was later than normal, and muscle contraction persisted longer than normal. Prolonged quadriceps activity may be a response to absence of soleus restraint, which stabilizes the flexed knee. The SACH foot occasioned longer quadriceps activity than did the single-axis model, possibly as a compensation for lack of dorsiflexion, which normally contributes to forward movement, as well as for the earlier heel rise experienced by SACH wearers. Hamstring activity was significantly higher with the SACH foot at midstance, again as presumed compensation for lack of dorsiflexion and earlier heel rise. The single axis foot was associated with biphasic hamstring activity. The second peak may aid knee flexion when the single-axis foot is worn, for the foot is 1.3 kg heavier than the SACH foot.

FINLAY O *(Royal Victoria Hospital, Belfast, Ireland).* **Footwear Management in the Elderly Care Programme.** *Physiotherapy* 72:172-178, 1986.

All 274 consecutive patients admitted to a geriatric hospital were screened for footwear. Foot measurements were taken in a weightbearing or simulated weightbearing position, as were footprints. Metatarsophalangeal height and first metatarsophalangeal joint angle were also recorded. Subjective data were obtained as was observational gait analysis. Footwear was required by 128 patients, about a quarter of whom wore slippers, a quarter had heels higher than recommended, and 20 percent had shoe heels which were too narrow. Nearly two-thirds had unsatisfactory heel counters. Hallux valgus was the most common foot deformity. Seventy percent had nail problems, and more than half had corns or callosities, especially the women. Two-thirds had foot swelling. Among the shoes provided, patients preferred leather uppers to corduroy. Most shoes had synthetic soles. Thirty percent of the shoes had long openings to ease donning.

Patients with hallux valgus required extra depth in the toe box; commercial shoes did not fit those whose forefoot depth exceeded 4 cm. When depth was greater than 5 cm, a molder thermoplastic toe box was needed. Only 13 percent complained of pain, supporting the theory that many older people accept foot discomfort as an inevitable accompaniment to aging. Slip-on footwear was associated with increased toe flexion during swing phase and the facilitation of good ground contact. A tenth of the group compensated for insufficient shoe width by purchasing shoes in unnecessarily large sizes. Soft uppers were essential, but incontinent patients could not use leather or suede. Frail elderly persons appreciated lightweight corduroy shoes with composition soles.

Recommended heel height was less than 3.6 cm, except for rheumatoid arthritics who required heels lower than 2.5 cm. A non-tapered last should be sought, and shoe construction should be solid if an orthosis is worn. Provision of carefully selected commercial footwear represented cost savings in comparison with custom or orthopaedic shoes.

FREY J, TECKLIN JS *(Department of Physical Therapy, Beaver College, Glenside, PA).* **Comparison of Lumbar Curves When Sitting on the Westnofa Balans Multi-Chair, Sitting on a Conventional Chair, and Standing.** *Phys Ther* 66:13367-1369, 1986.

Forty-four young healthy adults were measured while standing and sitting in two types of chair. A flexible metal ruler was molded to the back from the L1 to S2 spines. The shape of the lumbar curve was transcribed to paper and the curve was evaluated geometrically. One-way analysis of variance showed a significant difference among the mean lumbar curves measured while standing or sitting on the two chairs. The mean curve for standing was 31.2 degrees, -9 degrees for the conventional chair (indicating forward curvature), and -2 degrees

for the Balans chair. The Balans chair tilted the pelvis anteriorly, establishing a lumbar curve similar to the curve created in standing. Since test subjects were required to sit leaning forward to write at a desk, test results provide useful prescription data. Thus, the Balans chair would be appropriate for patients who would benefit from maintaining the lumbar curve approximating the standing lordosis. Well-designed chairs increase worker productivity; the Balans chair should reduce the harmful effects of sitting in flexion. Chair selection may be more helpful than the use of a lumbar orthosis or a sloped backrest, for the benefit of the orthosis is lost when the user moves forward to lean toward a desk.

GARRISON JH, SHANKARA B, MUELLER MJ *(Medical College of Wisconsin, Milwaukee, WI).* **Stroke Hemiplegia and Subsequent Lower Extremity Amputation: Which Side is at Risk?** *Arch Phys Med Rehabil* 67:187-189, 1986.

Review of the records of 22 amputees who had had a cerebrovascular accident indicated that 21 had ipsilateral hemiparesis. The mean time from onset of stroke to onset of amputation was 32.5 months for diabetics and 55 months for nondiabetics. The one subject with contralateral amputation subsequently had bilateral amputation. The relation between amputation and hemiparesis may be explained by its depressed temperature and blood flow decrease in the affected leg by 40 percent. The origin of altered temperature and blood flow may be increased by arteriolar tone, possibly caused by increased sympathetic neuron activity. Lesions in the higher control centers of the autonomic nervous system could cause circulatory impairments to the involved limb. In addition, loss of sensation in the involved leg presents greater risk for local, unnoticed trauma. Disuse and altered muscle activity, as present in hemiplegia, cause muscle fibers to experience decreased metabolic demands and reduced activity of oxidative enzymes. Other research has demonstrated lowered oxygen uptake, reduced blood flow, and diminished capacity to oxidize free fatty acids in the paretic leg.

These findings support the need for education concerning foot hygiene and skin protection, and for monitoring footwear and orthoses, especially among those who have drop foot. Rehabilitation that includes electrical stimulation may be desirable for increasing muscle activity and peripheral blood flow. Patients should be encouraged to remain ambulatory.

HAGEMAN PA, BLANKE DJ *(Division of Physical Therapy Education, University of Nebraska Medical Center, Omaha, NE).* **Comparison of Gait of Young Women and Elderly Women.** *Phys Ther* 66:1381-1387, 1986.

Gait analysis was performed with 13 women aged 20 to 35 years and 13 aged 60 or older. All were free of physical conditions which could affect gain; none were extremely lean or obese. Subjects were matched with regard to leg length. For gait analysis, subjects were photographed with high-speed cinematography cameras mounted at the side and end of the walkway as they walked barefooted at a self-selected pace. The only frontal or transverse plane variable which revealed a significant difference was pelvic obliquity; younger women had greater obliquity. No difference existed for pelvic or tibial rotationor lateral center of gravity excursion. However, significant sagittal plane differences included longer step and stride length as well as greater ankle movement and faster pace, among younger women.

The elderly women demonstrated step and stride lengths, velocity, pelvic rotation, and tibial rotation values comparable to those of young men and women reported in other studies, suggesting that the current subjects walk faster than their counterparts of 15 to 20 years ago. Stride width and center of gravity excursions were similar for both age groups.

HANAK R, HOFFMAN E *(New York University Medical Center, New York, NY).* **Specifications and Fabrication Details for the ISNY Above-Knee Socket System.** *Orthot Prosthet* 40:38-42, 1986.

The Icelandic-Swedish-New York (ISNY) above-knee flexible socket system was developed in a collaborative effort beginning in August 1982. The flexible socket may be made of a low-density molecularly aligned polyethylene, such as Ethylux, or Surlyn, a more rigid, optically clear plastic. Polyethylene is easier to draw, but has less memory retention than Surlyn, and tends to overstretch if used with bulbous amputation limbs. It is also much less expensive than Surlyn. Polyethylene creates a socket whose volume is closer to that of the model, providing better suspension. However, it shrinks

more than Surlyn in length. Socket thickness specifications were based on measurements from 30 sockets judged to have acceptable flexibility and durability. Wall thickness at midsection averaged 0.06 in., while proximolateral sections were 0.88 in. thick.

Socket edges should be rolled over the frame to insure adequate interlock and minimize socket tears. The socket should not be doffed by pushing on the proximolateral aspect as is done with a rigid suction socket.

The carbon-fiber reinforced laminated frame layup is 5 layers carbon fiber, 12 layers Fiberglas, and 5 layers carbon fiber for the medial strut; and 3 layers carbon fiber, 6 layers Fiberglas, and 3 layers carbon fiber for the anterior and posterior proximal extensions. Active and heavy individuals require additional carbon fiber. To aid saturation with polyester or acrylic resin, the carbon fiber is pierced with an awl to form channels for laminate entry.

HARBURN K, SPAULDING S *(Department of Occupational Therapy, University of Western Ontario, London, Ontario, Canada)* **Muscle Activity in the Spinal Cord-Injured During Wheelchair Ambulation.** *Am J Occup Ther* 40:629-636, 1986.

Electromyographic records were obtained from three nondisabled, three paraplegic, and three quadriplegic subjects. The quadriplegics' lesions were at C6 or C5, while the paraplegics had injury to T8, T9, and T12. All used the same model wheelchair with identical cushions. Surface electrodes were placed over the pectoralis major; biceps; anterior, middle, and posterior deltoid; and medial and lateral triceps. Twenty trials of 10 propulsive cycles were produced by each subject as they pushed in time with a metronome. Electromyographic cycles were selected for analysis on the basis of subject performance as judged from a videotape.

One quadriplegic achieved 50 percent maximum voluntary contraction of the pectoralis major, while the other subjects used the muscle minimally or not at all. The quadriplegics, one paraplegic, and one disabled subject demonstrated moderate biceps activity, especially during the part of the cycle corresponding to pressing the wheel forward. The middle deltoid was active in all subjects throughout the entire cycle. The lateral head of the triceps was minimally active in most subjects, as was the medial head.

The results are characterized by wide intersubject variability, even among nondisabled individuals. Inasmuch as the shoulder complex offers many movement possibilities, repetitive movements are quite variable. Quadriplegics employed the highest percentage of voluntary muscle contraction. Quadriplegics employed more motor units in each of their available muscles because they lack strong elbow extensors, precise grip, and trunk stability, thus taxing remaining muscles. Paraplegics were less efficient, as compared with nondisabled subjects.

HELM P, ENGEL T, HOLM A *(Hvidovre Hospital, Copenhagen, Denmark).* **Function After Lower Limb Amputation.** *Acta Orthop Scand* 57:154-157, 1986.

Investigators interviewed 107 adults 1 to 5 years after amputation. Although 78 had prostheses, 19 did not wear them for ambulation. Only half of the bilateral amputees had prostheses. Social dependence increased for 58 percent of the group, although two-thirds still resided in their own home. Two-thirds complained of phantom limb pain; pain did not correlate with sex, age, indication for operation, or level of amputation. Age and preoperative social condition were more determinant of postoperative social status than amputation level. Function was highest among unilateral below-knee amputees and poorest among unilateral above-knee and bilateral amputees. Women were older at operation, which possibly reflects the earlier onset of arteriosclerosis in men.

HITTENBERGER DA *(Seattle, WA).* **The Seattle Foot.** *Orthot Prosthet* 40:17-23, 1986.

Differences between walking and running were recorded on a Kistler forceplate at the Department of Kinesiology, University of Washington. In walking, the ground reaction force at heel contact barely exceeded body weight, but in running, the force was two to three times greater. Amputees had marked inability to push off after foot flat and exhibited drop-off. The Seattle foot was designed to eliminate drop-off by controlling and storing energy at early stance and releasing it during push-off.

After early experience with a novel Fiberglas keel developed at Prosthetics Research Study, Seat-

tle, Washington, Don Poggi and David Moeller of Model and Instrument Works, Seattle, redesigned the keel from Delrin 150, which provided adequate strength, lightness, moldability, and vibration dampening. The keel was covered with polyurethane foam molded to replicate male and female human feet. The current version has a Kevlar pad reinforcing the bottom of the forefoot. Because the Seattle foot is flexible in the metatarsal area, it does not limit forward tibial rotation, thus making it suitable for both walking and running. The authors describe the available keel configurations and sizes.

The Seattle foot is heavier than a SACH, but lighter than a SAFE or Greissinger foot. Those interested in maximum lightness for running should consider the Flex-Foot, while those who frequently walk on uneven ground may prefer the Greissinger or SAFE foot.

The Seattle foot cannot be used with the R.O.L. rotator or in the Syme's prosthesis. Alignment for the below-knee prosthesis should include reduced socket flexion and slightly greater toe-out. Alignment of the above-knee prosthesis differs from that appropriate with the SACH foot. Special techniques are required for securing the foot to endoskeletal shanks. The Seattle foot should not be worn barefoot.

HOLDEN MK, GILL K, MAGLIOZZI M *(Department of Psychology, Brandeis University, Waltham, MA).* **Gait Assessment for Neurologically Impaired Patients: Standards for Outcome Assessment.** *Phys Ther* 66:1530-1539, 1986.

Twenty-four individuals with multiple sclerosis and 37 with hemiparesis were assessed by means of an ink footprint record and by a timed performance rate obtained while the patient walked 20 feet.

Multiple sclerotics were younger, more independent ambulators, and less apt to use an orthosis as compared with hemiparetics. Both patient groups had time-distance scores well below normal values; sclerotics walked at 53 percent of normal velocity and hemiparetics at 41 percent. Cadence, step length, stride length, and ratio of stride to leg length were 57 to 72 percent of normal. Time-distance measurements for hemiparetics were consistently lower than for sclerotics, even for functionally independent subjects.

Measurements did not vary appreciably with the type of orthosis worn by hemiparetics, although etiology was associated with differences in velocity and step length. Velocity and cadence showed a stronger correlation to the type of ambulation aid than did the other measures. The type of ambulation aid used by sclerotics was significantly related to gait measures, especially velocity and cadence.

Setting goals for treatment outcomes should be based on values displayed by functionally independent neurologically impaired subjects rather than on values obtained from healthy subjects. Time-distance values must also be interpreted in light of the motor impairment level of the subject. The self-selected cadence of impaired subjects may be closer to maximal ability than is the case with healthy subjects who typically walk at velocity which is 44 percent slower than maximal velocity. Velocity may thus be a useful index of overall gait improvement; velocity combined cadence and stride length and correlates very highly with both measures.

Sclerotics performed better, possibly because of the slow progressive onset allowed from better functional adaptation, and they had fewer health problems, perceptual disorders, mental deterioration, and pain. Disability was more apt to be symmetrical. Subjects using an orthosis did not have significantly different values from those who did not have a device, perhaps because brace users derived stability from the orthosis while nonusers already possessed neuromuscular stability.

Hemiparetics with tumor had the slowest velocity, while those with trauma walked fastest, perhaps because the latter had better health and possibly a different pattern of cellular disturbance. The more supportive the ambulation aid, the lower the time-distance value. This suggests that an ambulation aid is a poorer choice than an orthosis for improving gait.

HUBBELL SL, COZEAN C, STANKO R *(Ohio State University, Columbus, OH).* **Fine Tuning of Swing Phase of Hydraulic Knees Using Gait Laboratory.** *Arch Phys Med Rehabil* 67:487-490, 1986.

Two amputees wearing Henschke-Mauch knee units were evaluated in the gait laboratory, which contained an 8-channel force plate and two solid-state array cameras. The instrumentation permitted the slopes of prosthetic knee angle motion to be compared to those of the sound leg within minutes. The hydraulic knee units were then adjusted to duplicate the tracings from the sound side. Forces

were also studied to verify symmetrical weight support. Evaluating the knee unit at various adjustment settings confirmed that flexion resistance affected extension resistance.

JOHNSON GR *(Department of Mechanical Engineering, University of Newcastle upon Tyne, England).* **The Use of Spectral Analysis to Assess the Performance of Shock-Absorbing Footwear.** *Eng Med* 15:117-122, 1986.

A major use of spectral analysis is the determination of transfer functions useful in examining the dynamic behavior of the foot-shoe interface. A test protocol was developed to evaluate the shock-absorbing capabilities of shoes with and without inserts.

A polypropylene splint molded over a plaster cast was fitted around the malleoli. An accelerometer fitted to the splint was connected by a cable to a signal conditioning unit in the pocket which was connected to the spectral analyser. The subject wore identical shoes and walked on a wooden floor laid over concrete. Some of the shoes worn by the subject were: Velcro fastening trainers; leather casual shoes with rubber heels and leather soles; loose casual shoes; and laced leather shoes with thick rubber soles and heels. Shoes were tested with and without a Sorbothane shock-absorbing heel insert.

The insert reduced acceleration in all cases. However, a large acceleration was recorded in the training shoe. Loose casual shoes and laced leather shoes produced similar tibial accelerations. Loose casual shoes had the greatest shock factor.

Large variations of spectra obtained with different footwear suggest that many design parameters govern shock reduction. Presumably, heel strike occurs because the foot has a finite absolute velocity at the instant of ground contact. Kinetic energy must be destroyed before stance phase can proceed. In order to reduce heel impact, stiffness must be reduced as much as possible; load reduction will be accompanied by increased deflection. A soft insert must be thick enough to allow increased deformation without "bottoming."

The role of hysteresis is to absorb elastic energy in stance. The insert must have short recovery time to recover full thickness during swing. The heel fat pad probably contributes to the hysteresis of the system. Reduction of shock factor resulting from an insert should be greatest for stiff footwear, as demonstrated in this study.

KAWAMURA I, KAWAMURA J *(Osada Rosai Hospital, Osada, Japan).* **Some Biomechanical Evaluations of the ISNY Flexible Above-Knee System With Quadrilateral Socket.** *Orthot Prosthet* 40:17-23, 1986.

Three linear motion transducers were used to measure the movement of the ISNY (Icelandic-Swedish-New York) socket walls. The potentiometers were attached to the central point of the anterior, lateral, and posterior sides of the socket. Foot switches on the prosthetic and normal shoe soles enable recording the phase of each leg. Three amputees were studied.

At heel contact the anterior wall collapses and the posterior wall expands. At midstance the lateral wall expands, and at push-off the anterior wall expands as the posterior wall reduces, corresponding with muscle contraction through stance phase. The degree of femoral adduction as measured by X-ray was the same in both the flexible and rigid socket. Four transducers along the length of the lateral wall revealed that the largest deviation was at the proximal second point. At heel contact the lateral wall expands rapidly and continues until push-off, to a miximum deviation of 5 mm. The distolateral wall expanded only 3 mm during stance phase, but showed the greatest collapse during swing phase. Thus, the lateral wall appears to hold the femur in the initial adducted position and changes contour to correspond to the soft tissue changes.

Measurement of socket thickness with a micrometer at 29 points revealed the maximum thickness was at the most distal point posteriorly, and the maximum thinness was at the distolateral aspect. The sockets were made of 4-mm polyethylene. The anterior and lateral walls were thinner.

LEHMANN JF, CONDON SM, DE LATEUR BJ *(University of Washington, School of Medicine, Seattle, WA).* **Gait Abnormalities in Peroneal Nerve Paralysis and Their Corrections by Orthoses: A Biomechanical Study.** *Arch Phys Med Rehabil* 67:380-389, 1986.

Six healthy young adults participated in a gait analysis investigation. They wore Blucher shoes; on the right shoe a rigid sole plate was attached with a

stirrup joining bilateral uprights which terminated at a rigid posterior calf band. Adjustable ankle joints were attached to the stirrups. Measurements were taken with an electrogoniometer attached to the stirrups. Measurements were taken with an electrogoniometer attached to the shoe heel and subject's calf, as well as a VICON motion analysis system, triaxial forceplate, and foot switch timer. Subjects walked unbraced, and after peroneal nerve block at 80 percent of normal cadence as guided by a metronome. They also walked unbraced, with the orthotic ankle set in 5 degrees plantar flexion, 5 degrees dorsiflexion, and with dorsiflexion spring assist.

Peroneal block caused shortening of the contralateral step without the brace. Time from heel strike to toe strike was shorter than normal. Orthoses did not affect the length of heel strike phase from normal. The first peak of ground reaction force was not altered by the block or orthoses, but the second peak was decreased by the block, and the aft shear was reduced. All orthoses increased the aft shear but did not restore normal force. Paralysis did not affect knee moments. The orthoses set in dorsiflexion increased the flexion moment at the knee. Plantar flexion moment during early stance was reduced by paralysis and restored with the orthosis set in either dorsi- or plantar-flexion, but not by the spring assisted device. Block increased the range of inversion and eversion; orthoses held the foot rigidly in neutral.

The optimum adjustment for a posterior orthotic stop maintains the minimum ankle angle for toe clearance to reduce knee flexion moment and excessive dorsiflexion during heel-strike and push-off. The spring-assist provided clearance but did not simulate the lengthening contraction of dorsiflexors at early stance.

MICHAEL JW *(Prosthetics and Orthotics, Duke University Medical Center, Durham, NC).* **Upper Limb Powered Components and Controls: Current Concepts.** *Clin Prosthet Orthot* 10:66-77, 1986.

Characteristics of the Otto Bock, Variety Village, Hugh Steeper, System-Teknik, University of New Brunswick, Fidelity Electronics, Hosmer Dorrance, Liberty Mutual, and Motion Control systems are presented. Otto Bock components are most utilized, while Hosmer is pursuing the inexpensive, low-tech market; and Motion Control seeks the high-tech, high-cost end. Lack of funding is probably the major factor limiting the use of powered fittings, for virtually any patient could operate an electric prosthesis. The highest failure rate occurs among patients with bilateral fittings.

The MyoBock system provides "myoswitch," nonproportional control. If the patient generates a sufficiently strong myoelectric signal, an electronic switch is triggered; a stronger signal will not produce a greater prosthetic effect. In contrast, the Fidelity Electronics system has proportional control: a mild signal causes slow prosthetic hand motion; a strong signal creates rapid powerful hand movement. The MyoBock prosthesis has two speeds: a quick gentle motion for opening and closing, and a slow powerful motion after the fingers grip an object. The third control is switch control, the least expensive and least bulky, requiring a rocker, a button, or a pull switch, or other variation. The MyoBock has a two-site version: one signal for hand opening and the other for closing.

The University of New Brunswick system is single-site/three-state; the signal opens, closes, or is off. The similar Bock system, "double-channel single-site," requires a quick impulse to open and a slow pulse to close the hand; the system should be called the one-site/two-function system. The Bock four-channel design has one electrode for opening and closing, and another for pronation and supination.

The Motion Control above-elbow system is proportional, with two sites for elbow flexion and extension, and terminal device opening and closing; electronic switching separates the elbow and hand functions, in sequential control. The ideal system simultaneous proportional control is not commercially available.

MILLSTEIN SG, HEGER H, HUNTER GA *(Ontario Workers' Compensation Board, Ontario, Canada).* **Prosthetic Use in Adult Upper Limb Amputees: A Comparison of the Body-Powered and Electrically-Powered Prostheses.** *Prosthet Orthot Int* 10:27-34, 1986.

Three hundred fourteen adolescent and adult unilateral/traumatic amputees responded to a questionnaire and had their records reviewed. The group included 12 women. Below-elbow was the site of amputation for more than half the group. Ninety-six percent owned a prosthesis, including 85 per-

cent with a cable-operated hook, 55 percent with a cable-operated hand, 25 percent with an electrically-powered hand, and 10 percent with a cosmetic prosthesis. Ninety-five percent of below-elbow amputees received a hook, but only 69 percent still wore it, as compared with 89 percent of above-elbow amputees who had a hook, of whom 73 percent continued to use it. Among the higher level amputees, 80 percent received a hook, but only 38 percent persisted with it. A third of below-elbow amputees received an electric hand prosthesis, and 82 percent continued with it, while only 9 percent of above-elbow amputees received an electric prosthesis, nearly all of whom still used it. All high-level amputees who received a powered prosthesis still wore it. Although most amputees who received a hook also had a cable-operated hand, few used the hand, and very few used a cosmetic prosthesis.

The hook was worn slightly less often than the electrically-powered hand during the day; cable-operated and passive hands were worn much less. Prostheses were worn less on the weekend. Pain was the principal reason for discontinuing prosthetic use altogether.

Two-thirds of the group used prostheses at work. Jobs involving light activities and contact with the public were more likely to be performed by those with the electric prosthesis. Weather influenced prosthetic use. Very cold temperatures interfered with battery function and made the amputation limb uncomfortably cold; hot humid weather caused sweating, which interrupted myoelectric control. Both types of prostheses were useful for daily activities and recreation. The hook was preferred for more vigorous sports. The electric hand was much more acceptable for social use.

Approximately a third of the group used the hook exclusively, and a third used two or more prostheses. Very few used the cable-operated or passive hand exclusively. Amputees stated the electric hand was most preferred, especially among high-level amputees. The advantages of the electric hand include increased comfort due to elimination or reduction of harness, cosmetic appeal, and greater pinch force. Disadvantages include higher cost, problems with maintenance, and greater weight.

MURPHY E *(New York, NY).* **In Support of the Hook.** *Clin Prosthet Orthot* 10:78-81, 1986.

A substitute for the human hand can represent a very limited compromise of the functions and appearance of the body part. Uncontrolled flexibility would be unstable, thus the prosthesis must limit joints severely with fixed, rigid curves. The customary wrist-disconnect unit permits interchange among various terminal devices. Existing hooks provide adequate force at any point in the opening range. They can be changed rapidly and delicately, and offer prolonged holding with substantial sensory feedback. The harness provides sensory feedback from kinesthetic awareness of joint position and tactual perception of pressure, in contrast to external power controlled by a valve, switch, or myoelectric signal which offers less sensory feedback. The hook is intrinsically more versatile than a mechanical hand of equivalent control and sophistication.

Remotely operated robotic manipulators take much longer to perform simple tasks as compared with the bare hands, yet bilateral arm amputees need little extra time to perform complex industrial and daily living tasks. Performance advantages of the amputee lie in basic design philosophy. Prosthetic hooks provide a fixed point of reference for arm placement in the fixed finger, allowing accurate positioning against the side of the object, followed by closing of the hook to surround the object securely. If both hook fingers move simultaneously, the user must position the arm in relation to an imaginary centerline while allowing for subsequent motion of the opposing surfaces, a more difficult task requiring good vision. The natural hand exerts only modestly more grip force than needed, while the amputee tends to overgrip. The prosthetic thumb may allow setting in a wide position, but does not permit the flattening needed to enter pockets. A hook remains slim near its closed position, yet can open to grasp wide objects. It can push, pull, pry, hammer, hold hot and cold objects, act as tweezers, and substitute for tools. Steel lyre fingers and alternative shapes, with canted axes, as well as the use of the color and cosmetic gloves, are dormant research issues. For instance, hook design for personal tasks, which are conducted close to the body, is conceptually different from hook design for vocational tasks, which are done at a table, since the tasks do not require wrist flexion.

PINZUR MS, DIMONTE-LEVINE P, TRIMBLE J *(Hines Veterans Administration Hospital and Loyola University, Stritch School of Medicine, Maywood IL).* **Temporal Gait Monitoring: A New Device.** *Arch Phys Med Rehabil* 67:334-345, 1986.

A new device, an event timer, which is nonencumbering to the subject, provides continuous gait recording with concomitant qualitative monitoring of the gait pattern. Instrumentation includes an ultrasonic transmitter-receiver system which records interankle distance and transducers strapped above the medial malleoli. The interankle distance records illustrate velocity during early and late swing phases. Heel strike occurs with abrupt upward deflection of the curve, and toe-off occurs with downward slope. The device has been used for the study of adult hemiplegic gait in conjunction with an electromyogram preamplifier and an electrogoniometer. Its accuracy compares very favorably with accepted standards.

PINZUR M, KAMINSKY M, SAGE R *(Hines Veterans Administration Hospital, Hines, IL).* **Amputations at the Middle Level of the Foot: A Retrospective and Prospective Review.** *J Bone Joint Surg* 68-A: 1061-1063, 1986.

Sixty-four amputations were performed at midfoot on 58 patients during a 5-year period. Patients had peripheral vascular disease with either gangrene or nonhealing ulcers. All were community walkers prior to amputation. Surgical level was determined by clinical examination and Doppler index. Amputations were transmetatarsal or Lisfranc with Achilles tendon lengthening. A well-padded short cast was applied in the operating room; the cast was changed 3 to 5 days later, when weightbearing with a cast-shoe and crutches or walker was allowed. A second cast remained until approximately 2 weeks after surgery. Sutures were removed at 3 to 4 weeks and patients wore standard laced shoes with a neoprene toe filler. Eighty-one percent of amputations healed, and all who had healing returned to community-walker status. Diabetics healed as readily as non-diabetics. One wound has broken down, requiring revision to below-knee level 4 years later. Late equinus has not developed, although nine patients developed late dynamic pes varus, of which most responded to an orthosis.

Postoperative foot deformity can be avoided by percutaneous Achilles tendon lengthening with special attention to the medial portion of the tendon. Nutritional supplementation enables successful distal amputation.

ROBERTS RA *(Veterans Administration Medical Center, San Francisco, CA).* **Suction Socket Suspension For Below-Knee Amputees.** *Arch Phys Med Rehabil* 67:196-199, 1986.

Fifty-six amputees fitted with below-knee suction prostheses responded to a survey; 466 prosthetists also completed a questionnaire. Experimentation with below-knee suction has been done since the 1950's. Suction is currently used with a) a rigid or semirigid insert socket, b) a socket with a soft liner, and c) a total contact silicone gel-lined socket which uses a sock and a latex suspension sleeve. Suction prevents pistoning on the skin and may improve circulation, allowing the calf muscles to assist venous return by cyclical pressure variations. Suction also allows for more normal reciprocal muscle activity than strap suspension.

Most of the amputees who responded to the survey were experiencing trauma. Suction sockets were worn all day, for an average of 9 years. All but one preferred suction to nonsuction. Most felt skin condition improved, and reported less pain. The prosthesis seemed lighter and had better appearance. The suction prosthesis did not require more adjustment than nonsuction. Most amputees stated that they could walk farther with suction suspension.

Fewer than a third of the prosthetists who responded had made suction prostheses. One prosthetist said he used suction on about half of his patients. Half of the prosthetists stated they felt suction was useful for a limited number of amputees, although 85 percent of those who had made them felt suction was suitable for selected amputees. Prosthetists made 40 positive and 831 negative comments; of the latter, the chief problem was fitting.

The suction technique is considered to be most appropriate for amputees who are physically active and who have residual limb problems. The low level of acceptance of suction suspension for below-knee prostheses may indicate the need for instructional courses that encourage more widespread use of this technique by prosthetists.

RADOCY B *(Therapeutic Recreation Systems, Inc., Boulder, CO).* **Voluntary Closing Control: A Successful New Design Approach to an Old Concept.** *Clin Prosthet Orthot* 10:82-86, 1986.

Introduction in 1980 of the "Prehensile Hand" revitalized interest in body power and voluntary closing control. Acceptance of the "GRIP" and children's "ADEPT" devices indicates that voluntary closing is a viable concept and confirms that poor performance, unreliability, and inappropriate design of early voluntary closing systems accounted for the dominance of voluntary opening systems.

Voluntary closing devices offer superior performance. Training is no more difficult, grip force range is expanded and directly proportional to output, reflex grasping is improved, shoulder muscles are used more effectively, and feedback sensations are more easily produced and assimilated to enhance control.

Voluntary closing body-powered devices should be prescribed as the primary complements to externally powered units, in view of the cost and reliability of powered devices, because limb and torso muscles are used more actively with the voluntary closing system, which can enhance externally powered control. New voluntary closing devices offer an opposed thumb and finger gripping configuration, similar to powered hands, so the user can incorporate learned patterns of gripping behavior, rather than split-hook prehension. Voluntary closing offers prehension forces greater than voluntary opening systems, thus encouraging bilateral function and prosthetic usage.

Design rationale include: natural prehension configuration, gripping surfaces to allow for a wide variety of holding tasks, simple design, and passive support and suspension by means of an internal hook or bump. The device requires continuous control to discourage muscle atrophy and allow for rapid reflexive grasping. It should be made of materials suitable for various age groups, and available in various weights and strengths.

The wearer is harnessed under controlled tension, rather than into a no-tension system, so the thumb is partially closed when the arms are relaxed at the user's sides. Northwestern No. 9 harness is excellent. Self-suspending sockets and ISNY flexible sockets may prove valuable. With partial-hand amputees, voluntary closing allows prehension in excess of 100 pounds.

STALLARD J, MAJOR RE, POINER R *(Orthotic Research and Locomotor Assessment Unit, Robert Jones and Agnes Hunt Orthopaedic Hospital, Oswestry, Shropshire, England).* **Engineering Design Considerations of the Orlau Parawalker and FES Hybrid System.** *Eng Med* 15:123-129, 1986.

The Parawalker (Hip Guidance Orthosis) enables reciprocal walking by those with complete spinal cord lesions at and above L1. The Parawalker is better than the swivel walker, which provides slow speed, can only be used on flat surfaces, and produces an unattractive gait. The Parawalker is supplied routinely to paraplegics in many centers in England.

Ambulation is facilitated by provision for clearing the swing leg which resists frontal plane collapse because of a rigid body brace to which leg orthoses are attached. The swing hip is moved from extension to flexion at the orthotic hip joint which incorporates a limited range of sagittal motion. Needle roller thrust and journal bearings ensure free orthotic motion in flexion-extension. Stops in the joint limit the arc of motion. The stance leg moves from flexion to extension aided by the patient's leaning on the ipsilateral crutch and by contraction of the latissimus dorsi to draw the trunk to the stance side. The Parawalker is comparatively easy to don.

Essential design features include a body brace to support the leg orthoses. Rigidity is achieved by cross bracing the aluminum alloy channel-section side members with a pair of stainless steel tubes. The chest support has a leather strap clamped to the side members. The sacral support band is polypropylene screwed to the hip joint. The hip joint has lateral stiffness, no lateral play, and simple operation. It is a two-part yoke assembly, with the lower member mounted on a needle roller journal and thrust bearing. Adjustable screw-stops permit adjusting the range of sagittal motion. Either aluminum or steel lower members may be used. Leg orthoses consist of bale operated knee locks, a polypropylene knee band with toggle clamp, and a shoeplate which permits the patient to wear unmodified shoes secured to the plate by a toggle clamp-secured polypropylene strap. The ankle has a fixed angle of 6 degrees dorsiflexion. Electrical stimulation of gluteal muscles supplements the orthosis in resisting adduction and aid hip extension.

THORNHILL H, JONES G, BRODZKA W *(Columbia University-Harlem Hospital Center, New York, NY).* **Bilateral Below-Knee Amputations: Experience With 80 Patients.** *Arch Phys Med Rehabil* 67:159-163, 1986.

Review of the records of all 80 persons who became bilateral amputees at the hospital or who were referred for rehabilitation revealed that 73 survived. The group was almost equally composed of men and women. Eight amputations were required because of trauma and one for alcohol-related sensory loss; the others were associated with obstructive arterial disease. All patients required some form of governmental funding. The mean age of the arteriosclerotics was 18 years older than those who sustainied trauma. Peak incidence of the second amputation was in the seventh decade. Nearly all arteriosclerotic patients were discharged home, while the non-arteriosclerotics were either institutionalized or lived alone. Arteriosclerotics had a mean interval of 23 months between amputations; 86 percent had diabetes.

Of the arteriosclerotics, 71 percent used bilateral prostheses at least three times a week. Men and those under the age of 60 were somewhat more likely to use prostheses. Of those unable to use bilateral prostheses, most had been unable to use a unilateral prosthesis. Mental impairment was the most common reason for the non-use of prostheses.

Arteriosclerotics survived an average of 44 months after the second amputation, allowing ample opportunity for rehabilitation while encouraging early discharge from the hospital. The arteriosclerotic person surviving bilateral amputation is among the fittest of unilateral peers in the survey, considering a mean survival of 2 to 4 years. Fewer than 5 percent had revision of the amputation limb, which supports the concept of preserving the knee joint.

All five patients who had been employed at the time of the second amputation returned to work. Psychosocial pathology was the major determinant of amputation of the eight nonarteriosclerotics and affected the ultimate use of prostheses and long-term disability pattern.

TURNER MS, CARUS DA, TROUP IM *(Dundee Royal Infirmary, Dundee, Scotland).* **Custom-Moulded Plastic Spinal Orthoses.** *Prosthet Orthot Int* 10:83-88, 1986.

Fifty consecutively fitted patients were reviewed with regard to their response to plastic jackets. Jackets were made of polyethylene or polypropylene molded over a plaster model of the trunk. The orthoses are not jointed and are closed with Velcro straps. They are lightweight, typically 0.5 to 1 kg, more attractive than metal/leather ones, easy to clean, impervious to perspiration, and very durable.

Patients with paralytic scoliosis, including those with osteogenesis imperfecta, muscular dystrophy, poliomyelitis, and spina bifida, derived benefit from a three-point force system with force under the axilla, at the contralateral distal thorax, and immediately proximal to the hip. One child with spina bifida used the jacket within a standing frame. Another wore the orthosis in bed to assist breathing. Those with nonparalytic scoliosis included adults with changes attributed to idiopathic scoliosis, children with cerebral palsy, and others with osteoporosis and neurofibromatosis. Eighty percent achieved pain relief and improved standing and walking. Only a third of the patients with kyphosis benefited from the jacket; the others complained of discomfort when sitting.

Four patients with localized vertebral body disease, such as from Paget's disease and tuberculosis, did not benefit from these jackets, which could not offer the needed distraction for pain relief. Half of the patients with low back pain achieved success with the jacket; most of them had worn fabric supports. Among those who failed with the jacket were four with definite psychological problems.

Prescription criteria for plastic jackets include paralytic scoliosis, where postural and breathing improvement may be expected, as well as better appearance. Nonparalytic scoliotics and kyphotics obtained pain relief; many used the jacket intermittently during the day. The jacket is inappropriate for those with localized vertebral body disease. Low back pain patients may benefit from plastic jackets if careful assessment is made. Jackets are most beneficial while the patient stands.

YASUDA YL, BOWMAN K, HSU JD *(Rancho Los Amigos Medical Center, Downey, CA).* **Mobile Arm Supports: Criteria for Successful Use in Muscle Disease Patients.** *Arch Phys Med Rehabil* 67-253-256, 1986.

Eighteen patients with Duchenne muscular dystrophy and eleven with spinal muscular atrophy,

who had been fitted with a standard mobile arm support, were studied by means of chart review, interview, and observation of performance. Range of elbow motion associated with successful use of the device may include contracture less than 25 degrees. Most patients had flexion contracture at the time of fitting, and successful device users presented increased contracture for which treatment is suggested. Successful users had at least poor positive elbow flexor power. Nonresistive, active use of weak muscles may have retarded decline in strength and prevented disuse atrophy. Neck and trunk stability proved to be very important; only one patient with sitting instability was unsuccessful in using the device. Those with surgical spinal fusion found the mobile arm support useful, but they could not use trunk motion to bring the hand to the face.

Family support was deemed essential for maintaining the equipment application and bringing patients to the clinic for follow-up. Patients who described the equipment as unacceptable in appearance were usually nonusers. The basic indicator for successful use was a need identified by the patient, such as self-feeding. The mobile arm support enabled patients to perform crafts and games skills and use the typewriter. However, the device's interference with operation of a motorized wheelchair was a complaint. Several patients used the device only for therapeutic reasons to maintain proximal limb strength and mobility.

Equipment adjustment problems included brackets attached too high on the wheelchair, misaligned troughs, incorrect horizontal and vertical adjustments, and dials obstructed by the lapboard. Adjustments will be needed when a new wheelchair is obtained or when the patient's physical condition changes.

A functional classification has been designed to match adaptive devices with the disabled person's needs, including motor, visual, and hearing impairments. Developers should expand use of a central clearinghouse to collect and disseminate information; consumers should have access to the clearinghouse which should categorize information on the basis of the functional limitations for which devices are suitable.